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BIOLOGY OF TWO JAPANESE SPECIES OF *METHOCA* WITH THE DESCRIPTION OF A NEW SPECIES (HYMENOPTERA, THYNNIDAE)*

By KUNIO IWATA

The biology of the genus *Methoca* LATREILLE (1805) has been studied so far with reference to the following four species:

M. ichneumonides LATREILLE—ADLERZ,[1] BOUWMAN,[2] CHAMPION brothers,[3] PAGDEN.[5]

M. stygia SAY—WILLIAMS.[4]

M. striatella WILLIAMS—WILLIAMS.[4]

M. punctata WILLIAMS—WILLIAMS.[4]

For the last few years I have had a good opportunities to make some observations on two Japanese species, *M. japonica* described by Mr. KEIZO YASUMATSU[6] of the Entomological Laboratory, Kyûshû Imperial University, and *M. yasumatsui* n. sp. to be described in this paper.

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* Contributions from the Entomological Laboratory, Kyoto Imperial University, No. 55.

1) ADLERZ, G. 1903, Arkiv för Zool., 1, 255—258; 1906, ib., 3, 1—48.
2) BOUWMAN, B. E.: 1909, Tijdschr. Ent., 52, 284—294, 296—299.
3) CHAMPION, H. G. and R. J.: 1914, Ent. Mon. Mag., 50, 266—270; 1915, ib., 51, 40—42.
4) WILLIAMS, F. X.: 1916, Psyche, 23, 121—125; 1919, Rept. Exp. St. Haw. Sug. Pl. Ass. Ent. Series, 14, 69—79.
5) PAGDEN, H. T.: 1925, Trans. Ent. Soc. London, 591—597.
6) YASUMATSU, K.: 1931, Kontyû, 5, 12—16: 1933, ib., 7, 141—143.

I. DESCRIPTION OF A NEW SPECIES

Methoca yasumatsui n. sp.

Female. Length: 5—7 mm.

Head and abdomen black; thorax, mandibles, antennae except 5—6 terminal segments, legs, posterior half of the first abdominal segment above and last 2 segments of abdomen red; ventral side of thorax and the constricted anterior portion of each thoracic segment usually black. Body slender, especially thorax. Head subtriangular, wider than thorax and twice as wide as mesothorax, narrower than abdomen. Mandibles slender, bidentate, setigerous; clypeus truncate, its anterior margin setigerous; a limited area before the antennal fossae a little raised on median line and shining; frons with scattered punctures and extremely fine longitudinal striae; genae shining and sparsely punctate with long hairs; compound eyes large and sparsely bearing hairs, its inner margins anteriorly diverging; ocelli forming an equilateral triangle; antennae densely pubescent especially at its distal portion, the last segment or tenth of flagellum longest (relative length of the 1st-10th segments of flagellum:—10 : 10 : 10 : 9 : 9 : 9 : 9 : 10 : 10 : 15). Thorax shining, very sparsely punctate and with yellowish setae, somewhat with very fine striae. Prothorax above with cervical region finely reticulate, separated posteriorly by a transverse furrow with few short longitudinal carinae, posterior margin of pronotum with distinct transverse striae; propectus anteriorly emerginate and strongly polished except the cervical portion, separated clearly from pronotum by conspicuous lateral sutures. Scutoprescutum exceedingly elongated anteriorly and becoming slender, coarsely with longitudinal carinae and with a shallow median pit near the anterior base of the large convex scutellum which is semi-ellipsoidal; anterior portion of mesosternite also strongly constricted and with strong but short longitudinal carinae; posterior portion of mesosternite raised gradually and with a mesal depressed line which forms posteriorly a small pit followed by transverse wrinkles; metanotum inconspicuous and occupying the constricted portion behind scutellum; metasternum posteriorly with a mesal nipple-like projection. Propodeum more or less spherical and widest at the caudal third of its length. Legs shining and with coarse setae, tibia of the middle legs with spines laterally, tibia and metatarsus of each leg provided with a cleaning apparatus, especially the elongated apical spur of the anterior tibiae just fitting against a semicircular pit in the

first tarsal joint. Abdomen petiolate and wider than head or thorax, strongly polished, impunctate, sparsely with long yellowish setae, petiol of the first abdominal segment with few longitudinal wrinkles. Ovipositor, when thrust out, nearly equal to thorax in length.

Male. Length: body 9—11 mm, fore wing 6—7 mm.

Body shining black except reddish-brown tip of mandibles, yellowishbrown palpi and brown tibiae and tarsi. Head subtriangular on dorsal aspect, nearly equal in width to mesothorax and wider than abdomen (3 : 2); clypeus shining, with a thorn-like prominence posteriorly on mesal line, its anterior margin gently projecting in the middle and with a semicircular gulf; area before the antennary sockets strongly concave; genaponta without a horn-like projection; mandibles stouter than in the female and setigerous; frons densely with strong punctures and bearing sparse setae as far as the posterior ocelli; genae polished and dorsad sparsely with setae; vertex shining impunctate; compound eyes bearing dense hairs and its inner margins slightly diverging posteriorly; ocelli in an equilateral triangle; flagellums densely with clothing hairs, scapes setigerous; lamellate process behind the antennary sockets deeply reticulate. Thorax shining and coarsely punctate, setigerous, widest at mesothorax; pronotum polished, anteriorly with transverse wrinkles followed by a shining truncation and by upturned neck region, laterally with a V-shaped depression; scuto-prescutum anteriorly with a median elliptic area which is bulged, posterior part of scutum flattened and rectangularly bordered, densely with coarse confluent punctures; mesopleurae strongly convex, with an inverse V-shaped carina near the antero-dorsal edge, shining with sparse punctures; ventral side of mesothorax strongly with a mesal furrow; tegulae with fine punctures proximad and shining distad; scutellum very sparsely punctate, with the anterior transverse sulcus; wings fusco-hyaline, the apex of the radial cell of fore wings nearly reaching the apex of the wings and the first transverse cubital nervure quite obsolete; metanotum with a semicircular median excavation. Propodium with short longitudinal carinae at the base and at the slope to apex, entire surface coarsely reticulate. Legs slender with the stout coxae and densely with long hairs. Abdomen slender, basal segment anteriorly with longitudinal carinae above and reticulate beneath; the 2nd—6th tergites transversely separated into two parts by a furrow which is deepest at the 2nd and gradually becoming shallow caudad, each anterior half very finely reticulate and each posterior half polished and bearing

hairs; the 3rd—6th sternites also with a deep transverse impression, each anterior half and hypopygium posteriorly with dense fine punctures, each posterior half glistening with very sparse punctures. Genitalia simple, outer lobe of stipes broad and middle lobe bilobed.

This species is related to the species from the Philippine Islands, *Methoca striatella* WILLIAMS, but it is different from them in the colouration of the female and the other structures in both sexes as previously shown.

Holotype:—Female; Ikeda, Settsu, Japan; July 14th, 1931; collected by the author.

Allotopotype:—Male; May 20th, 1931; collected by the author.

Paratypes:—Four females; Meguro, Tokyo, Japan; collected by Prof. YANO. Six females and 5 males reared in the summer of 1931.

Holotype and allotype are deposited in the Entomological Laboratory, Kyôto Imperial University. The species is gratefully dedicated to Mr. KEIZO YASUMATSU.

The outstanding differences between *M. japonica* and *yasumatsui* are as follows:

Structure	*M. japonica*	*M. yasumatsui*
Body of both sexes	stout	slender
Legs of both sexes	stout	slender
Antennae of both sexes	short	long
Head of both sexes	rectangular	subtriangular
Clypeus margin of male	with 4 teeth	with 2 teeth
Genaponta of male	with a horn	without a horn
Labrum of both sexes	angulate	round
Mandibles of both sexes	obtuse	sharp
Palpi of both sexes	stout	slender
Meso- and metathorax of female	not petiolate	petiolate
Abdomen of female	subpetiolate	petiolate

II. COLLECTION OF MATERIALS

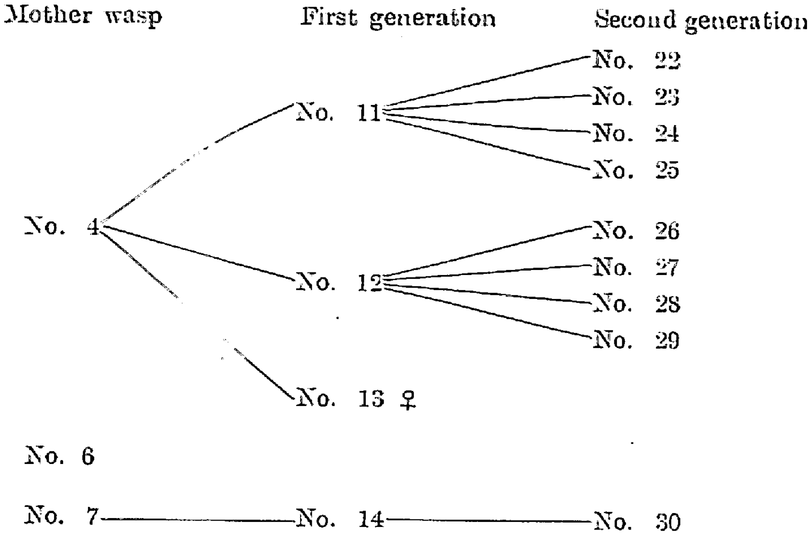
The *Methoca* wasps were first collected in Japan by Prof. M. YANO at Meguro, Tokyo many years ago. In July, 1930, I found a methocid and this was afterwards sent to Mr. YASUMATSU who described this as *M. japonica* YASUMATSU. This specimen was found attacking a tiger-

beetle larva in its burrow on a sandy area surrounded by the field of *Imperata koenigii.* All my insect materials concerned with this report were collected on the above mentioned field located along the River Ina, Province Settsu. In the summer of 1931 I also found a female of *M. yasumatsui* in the same locality, which also had been collected by Prof. YANO formerly at Meguro. The females of these species collected here are as follows:

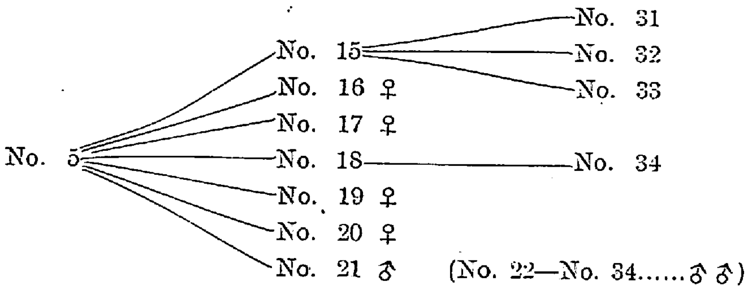
Wasp No.	Species	Date of collection
No. 1	*M. japonica*	2 p.m., July 2, 1930
No. 2	*M. japonica*	3 p.m., August 11, 1930
No. 3	*M. japonica*	3 p.m., August 11, 1930
No. 4	*M. japonica*	3 p.m., July 14, 1931
No. 5	*M. yasumatsui*	3 p.m., July 14, 1931
No. 6	*M. japonica*	2 p.m., July 27, 1931
No. 7	*M. japonica*	2 p.m., July 27, 1931
No. 8	*M. japonica*	11 a.m., June 10, 1932
No. 9	*M. yasumatsui*	11 a.m., June 10, 1932

The males of *Methoca* were difficult to collect in the field. At 10 a.m. on May 20, 1931 I collected a male of *M. yasumatsui* on a leaf of *Quercus acutissima* near the above mentioned field. That was the only example I was able to capture. Thus it is rather a rare occurence to meet with *Methoca* in the field, but on the other hand, it is easy to breed them artificially in a vessel and to observe their habits. In the summer of 1931 I made experiments with four of the females, Nos. 4, 5, 6 and 7. In the course of experiments I used about 80 larvae of *Cicindela specularis* CHAUDOIR. The *Cicindela* larvae are put one by one into the glass tube with the diameter of 2 cm., which is half filled with fine sands. As stated by CHAMPION brothers "the larvae readily make fresh burrows in captivity, or will even adopt and adapt artificial ones to their requirements." I also succeeded to get them to burrow in sands in the glass tubes in such a way that the activities within the burrow could be observed through the glass wall without disterbing the burrow itself. With the coming of September the larvae changed into the pupae. Consequently I was compelled to stop my observation. The wasps observed are numbered as follows:

1) *Methoca japonica*



2) *Methoca yasumatsui*



III. LIFE HISTORY

1) Development and Life of Imagos

So far as my studies in this locality go, both species are a natural enemy of *Cicindela specularis* CHAUDOIR (Iconogr. Ins. Jap., p. 831, 1932); but, according to Prof. YANO, *M. yasumatsui* attacks the larva of *Cicindela litterifera* CHAUDOIR at Meguro. Basing on the collections at the dune of Tottori, Hôki (deposited in the Entomological Laboratory, Kyôto Imperial University), I presume that *M. japonica* preys upon the grubs of *Cicindela litterifera* or *C. laetescripta* MOTSCHULSKY there. They probably overwinter in the larval condition under the ground and have several brood a year. The male seems to appear earlier than the female. The life history of these two species is very much like with one another.

The egg of *M. yasumatsui* is deposited on the ventral surface of the prey's abdomen, with its cephalic end directed towards the head of the victim. The egg of *M. japanica* is fixed behind the base of the metacoxa, with its cephalic end directed toward the mesal line of the prey. In both species the egg is about 0.8 mm long and 0.2 mm wide, somewhat curved ventrad, with strong glassy lustre and milky white in colour. The egg period, although it depends upon the temperature factor, is 1 or 2 days in mid-July. For examples, the egg period of *M. yasumatsui* is as follows:

Obs. No.	Date of oviposition	Date of hatching	Egg period
No. 5 (1)	11 a.m., 16—VII—'33	p.m., 18—VII	ca. 50 hours
No. 5 (2)	7 : 30 a.m., 18—VII—'33	10 a.m., 19—VII	26
No. 5 (4)	6 : 30 a.m., 19—VII—'33	4 a.m., 20—VII	21
No. 5 (5)	2 p.m., 19—VII—'33	noon, 20—VII	22

It may be added here that it rained every day from July 17 to July 20.

The hatched larva sucks in the body fluid of the host at the point where the egg was fixed. After sucking up the fluid the larva devours the tissues under the skin, completely leaving at last only the head capsule and the body wall of the grub, in a week or so, as shown below:

Obs. No.	Date of oviposition	Date of fullgrowth	Duration
No. 5 (1)	a.m., 16—VII	p.m., 23—VII	7 days
No. 5 (2)	a.m., 18—VII	a.m., 27—VII	9
No. 15 (2)	a.m., 15—VIII	a.m., 22—VIII	7
No. 15 (3)	p.m., 15—VIII	a.m., 22—VIII	7
No. 18 (4)	p.m., 4—IX	a.m., 11—IX	7
No. 7 (2)	p.m., 29—VII	a.m., 6—VIII	7.5
No. 11 (1)	a.m., 19—VIII	a.m., 26—VIII	7
No. 11 (3)	23—VIII	30—VIII	7
No. 11 (4)	p.m., 24—VIII	a.m., 1—IX	7.5
No. 11 (5)	p.m., 25—VIII	2—IX	7.5
No. 12 (1)	p.m., 20—VIII	a.m., 27—VIII	7.5
No. 12 (2)	21—VIII	a.m., 28—VIII	7
No. 12 (3)	p.m., 22—VIII	p.m., 29—VIII	7
No. 12(10)	1—IX	a.m., 10—IX	9
No. 14 (2)	p.m., 5—IX	a.m., 13—IX	8

After finishing the spinning of its cocoon in about 2 days, the larva excretes excrements on the bottom of the cocoon and thereafter remains in quiescence. The size of the fullgrown larva is very variable according to the conditions of the preys. The larva can not spin the cocoon when the burrow or test tube given to them is larger than their normal habitat, that is, the *Cicindela* burrow which has a diameter of about 5 mm. They fail to spin cocoons when the space provided for them is longer than 2 cm. and wider than 1.5 cm. In the *Cicindela* burrow the larva spins at first a dish-like partition overhead, locking out the residual skin of the prey upwards, and under this partition the cocoon-cover and cocoon. The cocoons are spindle-shaped and dirty yellowish-brown in colour when the moisture condition is normal, while under a dry condition they spin pure white ones. Such white cocoons become quickly brown when exposed to moist air. The inner surface of the cocoon is polished. Generally the cocoons resemble to those of the burrowing Psammocharids, *Psammochares* and *Batozonus*. Removing the cocoon-cover the size of their cocoons are as follows:

	Obs. No.	Issued wasp No.	Sex	Length	Width	Average	
						Length	Width
M. yasumatsui	No. 5(1)	No. 18	♀	9 mm	3 mm	9 mm	2.5 mm
	No. 5(2)	No. 15	〃	7	2		
	No. 5(4)	No. 16	〃	8	3.5		
	No. 5(?)	No. 17	〃	10	4		
	No. 5(8)	No. 19	〃	10.5	3		
	No. 5(10)	No. 20	〃	11	3.5		
	No. 5(6)	No. 21	♂	12.5	4	11 mm	3.5 mm
	No. 15(3)	No. 33	〃	10	3		
	No. 15(4)	No. 32	〃	12	3		
	No. 15(8)	No. 31	〃	9	2.5		
M. japonica	No. 4(6)	No. 11	♀	8 mm	2 mm	9 mm	3 mm
	No. 4(10)	No. 12	〃	10	3		
	No. 4(?)	No. 13	〃	10	3.5		
	No. 7(3)	No. 14	〃	7	2		
	No. 11(3)	No. 22	♂	12.5	3.5	12 mm	3.5 mm
	No. 11(4)	No. 24	〃	12	3.5		
	No. 11(5)	No. 23	〃	13	3.5		
	No. ?	No. 25	〃	12	3.5		
	No. 12(2)	No. 26	〃	11.5	3.5		
	No. 12(?)	No. 27	〃	11	3.5		

Thus in both species, the male which is usually larger than the female emerges from the larger cocoon.

The total quiescent period in cocoons, i.e., the resting larval and pupal periods together, is very variable, even when retained under the same condition.

	Obs. No.	Issued wasp No.	Sex	Finish of spinning	Emergence from cocoon	Total quiescent period
M. yasumatsui	No. 5(1)	No. 18	♀	25—VII	28—VIII	34 days
	No. 5(2)	No. 15	〃	29—VII	11—VIII	13
	No. 5(4)	No. 16	〃	30—VII	12—VIII	13
	No. 5(6)	No. 21	♂	3—VIII	27—IX	55
	No. 5(10)	No. 20	♀	17—VIII	23—IX	37
	No. 15(3)	No. 33	♂	24—VIII	21—IX	28
	No. 15(8)	No. 31	〃	4—IX	22—IX	18
M. japonica	No. 4(6)	No. 11	♀	2—VIII	15—VIII	13
	No. 4(10)	No. 12	〃	5—VIII	18—VIII	13
	No. 11(3)	No. 22	♂	1—IX	24—IX	23
	No. 11(4)	No. 24	〃	3—IX	26—IX	23
	No. 11(5)	No. 23	〃	4—IX	26—IX	22
	No. 12(2)	No. 26	〃	30—VIII	21—IX	22

This difference in the total quiescent period causes the disagreement in the total developmental period. It is, however, questionable whether these periods observed in captivity coincide with those in the field, where the sands are extremely hot by day and cold by night.

The sands of the glass tubes in which the wasp cocoons were put were kept always moderately wet and these tubes were placed on the same shelf. Notwithstanding the similarity in the rearing condition, the periods of some individuals became greatly different, for instance between No. 5 (1) and No. 5 (2) in the following table. In this case the *Cicindela* larva attacked by No. 5 (1) was before the ecdysis and fat, while that of No. 5 (2) was just after the ecdysis and quite lean. Thus, on some occasions, the difference in the physiolosical conditions and hence probably in the nutritive values of their preys seems to have some influence on the length of the developmental period of the wasps.

M. yasumatsui				*M. japonica*			
Obs. No.	Issued wasp No.	Sex	Total period	Obs. No.	Issued wasp No.	Sex	Total period
No. 5(1)	No. 18	♀	43 days	No. 4(6)	No. 11	♀	25 days
No. 5(2)	No. 15	〃	24	No. 4(10)	No. 12	〃	23
No. 5(4)	No. 16	〃	24	No. 7(3)	No. 14	〃	35
No. 5(8)	No. 19	〃	50	No. 11(3)	No. 22	♂	32
No. 5(10)	No. 20	〃	48	No. 11(4)	No. 24	〃	33
No. 5(6)	No. 21	♂	66	No. 11(5)	No. 23	〃	32
No. 15(3)	No. 33	〃	37	No. 12(2)	No. 26	〃	31
No. 15(8)	No. 31	〃	27	No. 12(4)	No. 28	〃	40
No. 18(4)	No. 34	〃	29	No. 14(2)	No. 30	〃	28
Maximum		♀	50	Maximum		♀	35
		♂	66			♂	40
Minimum		♀	24	Minimum		♀	23
		♂	27			♂	28

The food and duration of the adult life of these wasps in nature are unknown. In captivity when fed on diluted honey soaked in cotton, they lived fairly long as shown below:—

M. yasumatsui	*M. japonica*
No. 5* more than 32 days	No. 4* more than 20 days
No. 15 16 days	No. 6* more than 14 days
	No. 7* more than 11 days
(* Imagos collected in the field, whose life before they were discovered is unknown.)	No. 12 17 days
	No. 22 30 days
	No. 23 15 days
	No. 24 12 days
	No. 25 13 days
	No. 27 25 days

The female of these species are active only by day and rest by night. The females kept in vessels with sands burrow in sands and remain inactive doing nothing except when they attack the *Cicindela* larva or fill the burrows of the latter. Both males and females are not active in a rainy or cloudy weather. In clear day-time the males become active and try violently to get out of the vessels (positive

phototaxis), while the females never show such an action. The activity of the females is also increased when exposed to the direct sun-light and there the nesting habit is more rapidly carried out. It was impossible to make them copulate in vessels, although often tried. In nature the copulation may take place in the air as many *Mutilla* and *Myrmosa* do.

2) Oviposition and Parthenogenesis

The females of these two species of *Methoca* deposit generally one egg a day, although sometimes two eggs a day and one egg per two days. I could not make them oviposit three times a day although I tried it often. When the females are compeled to attack the tiger-beetle grubs twice a day, first in the morning and second in the afternoon, they deposit an egg either in both occasions or only once in either of them. In the latter case they oviposit almost always in the morning and not in the afternoon. The preoviposition period is not exactly known. Five females, viz., Nos. 15, 18 (both *yasumatsui*), 11, 12 and 14 (all *japonica*), were able to deposit eggs from one to four days after their emergence from cocoons. It is impossible to point out how many eggs one female deposits in the course of her life. In captivity they laid about ten eggs during their life.

M. yasumatsui	*M. japonica*	*M. yasumatsui*	*M. japonica*
collected in the field		reared from eggs in vessels	
No. 5......10 eggs during 25 days	No. 4......8 eggs during 20 days No. 6......6 eggs during 11 days No. 7......3 eggs during 6 days	No. 15......6 eggs during 13 days	No. 11......8 eggs during 11 days No. 12......10 eggs during 12 days

The females of *Methoca yasumatsui* and *japonica* reproduce parthenogenetically[7] and the virgin eggs produce only the males, that is,

7) PAGDEN states in his paper (1925, loc. cit., p. 597): "It seems, therefore, that the scarcity of the males of *Methoca ichneumodides* is due, at least in part, to the fact that the female is capable of parthenogenetic reproduction...... Whether male or female *Methoca* will emerge from the five cocoons cannot yet be told."

arrhenotocous.[8] As it is impossible to induce the confined females to mate in vessels, only males emerge from the cocoons of the second generation, although both sexes emerge from those of the first generation. Without the act of fertilization the five females, viz., Nos. 15, 18 (*yasumatsui*), 11, 12 and 14 (*japonica*), began to attack the tiger-beetle larvae and deposit eggs. The total number of the virgin eggs thus deposited was 30 (10 of *yasumatsui* and 20 of *japonica*), of which 14 eggs failed to hatch or the larvae died immediately after hatching and 16 eggs hatched normally and gave rise to aestivation larvae. From 13 out of these 16 cocoons, the male wasps emerged after about a month of aestivation as follows:

Mother wasp No.	Number of virgin-eggs	Number of dead		Number of issued males
		Eggs	Dormant larvae	
No. 15	6	2	1	3
No. 18	4	3	0	1
No. 11	8	4	0	4
No. 12	10	4	2	4
No. 14	2	1	0	1
Sum	30	14	3	13

8) Some papers concerning the arrhenotoky in Hymenoptera are as follows:
(i) Vassiliew, J.: 1907, Ueber neue Falle von Parthenogenese in der Familie der Chalcidida. Zeits. Wiss. Insbiol., 3, 386—387.
(ii) Swezey, O. H.: 1913, Parthenogenesis in *Melittobia*. Proc. Hawaiian Ent. Soc., Vol. 2, 194.
(iii) Nowell, W.: 1915, Two Scoliid Parasites on Scarabaeid Larvae in Barbados. Ann. Appl. Biol., Vol. 2, 51.
(vi) Davis, J. J.: 1919, Contributions to a Knowledge of the Natural Enemies of *Phyllophaga*. Bull. Dept. Reg. Ed. Div. Nat Hist. Surv., Illinois, Vol. 13, Art. 5, 66.
(v) Bischoff, H.: 1927. Biologie der Hymenopteren. 491—494.
(vi) Yamanaka, M.: 1928, On the Male of a Paper Wasp, *Polistes fadwigae* Dalla Torre. Sc. Rep. Tohoku Univ., Sendai, Japan, 3, 265—269.
(vii) Wheeler, W. M. 1928, The Social Insects. 162—165.
(viii) Meisenheimer, J.: 1930, Geschlecht u. Geschlechter im Tierreiche. Bd. 2, 52—60.
(ix) Noll, Josef: 1931, Untersuchungen ueber die Zeugung und Staatenbildung des *Halictus malachurus* Kirby. Zeits. Molph. Okol. Tiere, Bd. 23, 285—368.

Thus 57 % of the virgin eggs perished before developing into the adult stage; while, however, 48 % of the fertilized eggs failed to develop normally, viz., 13 out of 27 eggs died before or immediately after hatching and 14 eggs gave rise to the male and female wasps.

IV. BEHAVIORS OF THE FEMALES

The females of *Methoca yasumatsui* and *japonica* appear onto the sandy localities in late spring, when the larvae of *Cicindela specularis* attain the length of 10—15 mm. and dig the burrows with the diameter of 3—4 mm. The females attack the grub in or out of the burrow, preserve it making use of the host's burrow, deposit an egg on the prey and fill up the burrow with sands. The stinging and oviposition habits of the females are very different in the two species. The following observations were made mostly from these points of view. With 9 females, viz, Nos. 5, 15, 18 (*yasumatsui*), 4, 6, 7, 11, 12 and 14 (*japonica*), about 80 observations were made during 50 days in the summer of 1931. Sixty-five examples out of eighty are shown below and the other examples where no responses on the part of the wasps were elicited are omitted. In 17 cases that are indicated with* in the following table, the wasps stung the prey at the top of the burrow and their stinging habit was exactly observed, but in the other 48 cases they attacked the preys inside of the burrow and it was very difficult to observe the quick paralysis-action through the glass which formed the one wall of the *Cicindela* burrow.

A. Observations

M. yasumatsui

Obs. No.	Date of observation	Scene of attack	Oviposition
No. 5 (1)	10 a.m., 16—VII	T*	+
No. 5 (2)	7 a.m., 18—VII	T*	+
No. 5 (3)	3 p.m., 18—VII	I	+
No. 5 (4)	6 a.m., 19—VII	I	+
No. 5 (5)	2 p.m., 19—VII	I	+
No. 5 (6)	21→24—VII	I	+
No. 5 (7)	p.m., 27—VII	I	—
No. 5 (8)	10 a.m., 2—VIII	I	+
No. 5 (9)	p.m., 2—VIII	I	—

Continued

Obs. No.	Date of observation	Scene of attack	Oviposition
No. 5 (10)	10 a.m., 6—VIII	I	+
No. 5 (11)	5 p.m., 6—VIII	I	+
No. 5 (12)	a.m., 7—VIII	I	+
No. 15 (1)	11 a.m., 14—VIII	I	+
No. 15 (2)	11 a.m., 15—VIII	I	+
No. 15 (3)	p.m., 15—VIII	I	+
No. 15 (4)	p.m., 17—VIII	I	+
No. 15 (5)	a.m., 19—VIII	I	—
No. 15 (6)	a.m., 23—VIII	I	+
No. 15 (7)	p.m., 23—VIII	I	—
No. 18 (1)	10 a.m., 30—VIII	T*	+
No. 18 (2)	a.m., 1—IX	I	+
No. 18 (3)	10 a.m., 3—IX	I	+
No. 18 (4)	p.m., 4—IX	I	+
Total	23 observations	20 I, 3 T	+19, −4

M. japonica

Obs. No.	Date of observation	Scene of attack	Oviposition
No. 4 (1)	10 a.m., 16—VII	O*	+
No. 4 (2)	6 a.m., 18—VII	O*	+
No. 4 (3)	3 p.m., 18—VII	O	+
No. 4 (4)	6 a.m., 19—VII	I	—
No. 4 (5)	10 a.m., 20—VII	I	+
No. 4 (6)	21→24—VII	I	+
No. 4 (7)	21→24—VII	O	+
No. 4 (8)	21→24—VII	I, O*	+
No. 4 (9)	a.m., 25—VII	I, O*	—
No. 4 (10)	p.m., 27—VII	I	+
No. 4 (11)	p.m., 2—VIII	I, O*	—
No. 6 (1)	p.m., 27—VII	I	+
No. 6 (2)	29→30—VII	I	+
No. 6 (3)	10 a.m., 2—VIII	I	+
No. 6 (4)	p.m., 2—VIII	I, O*	—
No. 6 (5)	10 a.m., 3—VIII	I	+
No. 6 (6)	5 p.m., 5—VIII	O*	+

Continued

Obs. No.	Date of observation	Scene of attack	Oviposition
No. 6 (7)	10 a.m., 6—VIII	I, O*	+
No. 7 (1)	p.m., 27—VII	I	+
No. 7 (2)	29—→30—VII	I	+
No. 7 (3)	p.m., 30—VII	I	+
No. 7 (4)	p.m., 2—VIII	I	—
No. 11 (1)	10 a.m., 19—VIII	I*	+
No. 11 (2)	21—VIII	I	+
No. 11 (3)	23—VIII	I	+
No. 11 (4)	2 p.m., 24—VIII	I	+
No. 11 (5)	Noon, 25—VIII	I, O*	+
No. 11 (6)	p.m., 26—VIII	I	+
No. 11 (7)	a.m., 30—VIII	I	+
No. 11 (8)	1 p.m., 30—VIII	I	+
No. 12 (1)	2 p.m. 20—,VIII	I	+
No. 12 (2)	21—VIII	I	+
No. 12 (3)	3 p.m., 22—VIII	I, O*	+
No. 12 (4)	1 p.m., 23—VIII	I	+
No. 12 (5)	11 a.m., 24—VIII	I	+
No. 12 (6)	1 p.m., 25—VIII	I, O*	+
No. 12 (7)	3 p.m., 26—VIII	I	+
No. 12 (8)	27—→28—VIII	I, O*	+
No. 12 (9)	9 a.m., 30—VIII	I, O*	+
No. 12 (10)	1—IX	I	+
No. 14 (1)	4—IX	I	+
No. 14 (2)	5—IX	I	+
Total	42 observations	27 I, 15 O	+37, —5

(T = top of, I = in, O = out of the burrow)

The female wasps recorded in the following observations were all kept one by one in glass jars being fed on diluted honey soaked in cotton and were removed from these breeding jar into the vessels containing each one *Cicindela* grub only when they were got to fight against it.

Some of these observation records run as follows:

a. Methoca yasumatsui IWATA

1) No. 5 (1) [Captured on July 14]

The wasp was transfered into the *Cicindela* jar at 9 : 50 a.m.:

It was her first encounter with a prey after being captured. She did not enter the burrow, but walked on sands and up and down on the vertical wall of the tube. At 10 a.m. she found the burrow. As soon as she recognised its cephalothoracic shield that covered up the entrance to the burrow, she retreated back quickly and put herself in a posture of defence at the distance of 8 mm. from it, facing towards it and stretching her antennae forwards. For 15 minutes she remained in such an immobile posture, only vibrating her antennae too rapidly to be recognised. At 10 : 15 a.m. she approached 3 mm. to the larva, in such a slow motion as a mantis steals up to its prey, although vibrating her antennae as it was. At 10 : 21 a.m. suddenly she stopped the vibration, rushed at the grub's shield——at that moment the grub threw back its head quickly and seized her between its jaws—bent her abdomen enough and stung the grub behind the mesal portion of its gular region. Soon after stinging the grub set her free and she retreated back. Again she approached the prey which had been completely paralyzed and remained quiet occupying the mouth of the burrow. She touched it slightly with her antennae that had aeready stopped vibration. At 10 : 25 a.m. she went down the burrow squiezing herself through the entrance clogged by the paralyzed larva and after a short time began to pull it down seizing its abdominal extremity with her mandibles. At 10:30 a.m. she reached at the bottom of the burrow (11 cm. below the entrance). At 10:45 a.m. she began to drag the larva again upwards grasping it by its mouth-appendages, put it at the level of 2.5 c.m. below the entrance and went down again. At 11 a.m. she was engaged in filling-up the burrow with sands. She transported sand particles one by one from the outside near the burrow holding them with mandibles. The next day the burrow was dug up and found to have been filled up at the lower 2.5 cm..

2) No. 5 (2)

The wasp was put into a vessel at 7 a.m.. The larva was deep in the burrow. Soon she found the burrow and went down the latter. She came out of the burrow, again went down and at once came out again, but it was not likely that she attacked it. At 7:05 a.m. she entered into the burrow for the third time and quickly appeared near the entrance head first, being followed by the larva. There she turned about and in a moment stung it behind the middle of the gular region. It went down deep into the burrow. At 7:30 a.m. she pulled it up near to the entrance. After a while she pulled it down the

burrow again. At 7:54 a.m. she appeared out of the burrow, which she began to fill in. She walked about round the mouth of the burrow, found a suitable sand particle, grasped it with mandibles, carried it into the burrow, placed it on the half-buried burrow, pressed the surface with her clypeus and these actions were repeated. In the last phase of actions she pressed down the filling of the burrow without leaving hold of the small pebble she had brought from outside with her mandibles and sometimes tamped down sands into burrow 5 times with this tool. The *Methoca* walked very slowly, for examples, it took 4 minutes for her to collect, transport and lay 32 pebbles in her burrow. At 8 a.m. I stopped my observation. The burrow was dug up and found that it was filled in with sands 2 cm. below the larva and 1.5 cm. above it (vide the figure).

3) No. 5 (4)

As soon as the wasp was put into the jar, in which the *Cicindela* grub hid itself deep in the burrow. She went down the burrow and soon came out head first followed by the irritated larva. The larva quickly went down, immediately came out again, soon got down the burrow deeply again and never appeared; while the huntress retreated out of the burrow and stayed still directing her head towards entrance. After a short time she began slowly to go down the burrow for the second time, while the larva remained motionless in complete paralysis. The effective sting might be thrust behind the gular region at the first encounter.

4) No. 5 (6)

The wasp paralysed the prey in the burrow. I dug up the burrow. The *Cicindela*'s burrow was 70 mm long. The paralysed larva was preserved at the bottom, and the burrow was filled with sands 5 mm above its cephalothoracic shield. There was an empty space of 15 mm upwards. The uppermost 35 mm of the burrow was filled with sands and at the entrace the surface was smoothed as shown in the figure.

5) No. 5 (12)

I dug up the burrow. The burrow had been 34 mm long. At the bottom was preserved the larva, above whose cephalothoracic shield 5 mm of the burrow was filled with fine small sands and the upper 8 mm was tamped with the comparatively coarse pebbles which were clearly brought into one by one by her with mandibles. Near the mouth 4 mm remained yet not plugged (vide the figure).

6) No. 18 (1) 〔Emerged on August 28〕

This female wasp was the daughter of the preceding female No. 5. The following observation was done on August 30, two days after her emergence, and it was the very first chance for her to meet with the *Cicindela* grub. The artificial burrow for the larva was so carefully prepared along the glass wall, that all the occurences in the vessel were visible through this wall. At 10 a.m. the wasp recognized the cephalothoracic shield of the grub which was occupying the entrance of the burrow. She slowly approached the entrance and at once retreated back, always directing her head towards it——and repeated these actions three times. The top of the burrow was funneled and the mouth opened at bottom. Now she stepped up to the top of the slope and looked down the grub for the fourth time and stayed still vibrating her forward stretched antennae rapidly and continuously, as if she were watching for a convenient moment to sting the prey. I beat slightly the outside of the glass tube at the point near the burrow entrance with a pencil. In a moment she rapidly rushed at the larva and quickly retreated back as a praying insect does when it attacks its prey. I tried this experiment several times. The stronger I beat the vessel, the nearer she rushed at the grub and the more conspicuous she assumed an offensive attitude, strongly curving her abdomen ventrad towards the prey; while the prey, without changing its posture, stayed still at the entrance directing its jaws towards the aggressor. It never threw back its head. Next I suddenly made the pencil approach to the two confronting insects to animate them with provident care not to beat the outside of the vessel. Although I tried several times, she did not dash at the prey. This will suggest that she did not respond to the sudden stimulus on to her visual sense. Now I beat slightly the vessel wall with the pencil near the entrance, and then I found she dashed quickly at the grub. Next I beat the vessel wall at any other points invisible for the wasp and yet I observed her active dashing. Thus it will be evident that the shock by the pencil stroke caused the sensible wasp to attack the prey against which she had been watching for a chance. Quickly she rushed at it—never flung herself into the large jaws as observed in other females—curving her abdomen strongly ventrad and stretching her long sting forwards, and in a moment again retereated back. The attacking seemed to have ended in a failure for her; for even her legs did not touch the prey, a point behind the prey's gular region was distant as long as

5 mm. from her abdominal end (the body length of this wasp was 6mm. and her sting was presumed to attain 3 mm. long), the prey did not threw back its head and so did not afford facilities to the wasp for attacking, and yet its cephalothoracic shield covered the entrance as it had been. But in point of fact, the larva had been completely paralyzed. She retreated back and walked about in the vessel.

b. Methoca japonica YASUMATUS

7) No. 4 (1) [Captured on July 14]

As soon as the wasp was transfered into the vessel, she recognized the grub at the entrance at 10:57 a.m. She did not leave the environs of the entrance, often approached to the prey rapidly, sometimes ran across over the grub's cephlothoracic shield.

Excited by this, at last, it threw back its head trying to remove the falling sands from the entrance burrow and attempt to snap at its adversary. But at that instance it exposed all its unarmed thoracic points and so she quickly rushed at it to cling to its ventral surface. It jumped out of the burrow and walked about for a moment with its enemy which clung to it obliquely, venter to venter, in adverse direction for it. She stung it quickly at a mesal point of its neck region and soon departed from it. It bent itself ventrad in U-shape and lay helplessly on sands. Within a while she clung herself to its dorsal side in adverse direction, bent her abdomen round the sinistral side of its abdomen and stung secondarily behind the basal portion of its sinistral metacoxa being responded by its short struggle. Departed from it she went down the burrow, came up soon and began to pull the completely paralyzed prey, whose abdominal extremity was seized with her mandibles. But she could not transport it, for it is too heavy for her. She let go it, went down the burrow again, came out once more and began to drag it holding by the dorsal projection on its 5th abdominal segment with her mandibles. At the entrance she changed her holding point to the caudal extremity and drew it down into the burrow slowly.

8) No. 4 (2)

At 6:30 a.m. the wasp was introduced into the vessel near the grub which was just at the burrow entrance. Quickly recognising it, she rushed to it, touched it with her antennae and rapidly retreated back directing her head towards it. These motions were repeated

5 times and stimulated it so strongly that it exposed its upper half of the body from the burrow. Instantly clung she to the dorsal surface of the grub's thorax curving her abdomen between the grub's mandibles and stung it rapidly behind the gular region. It jumped out of the burrow and walked on sands rather sluggishly; while she, as she had not departed from it, crawled on its ventral surface and at last fixed herself tightly to its first and second abdominal surface seizing its thoracic sternum with her mandibles. She plunged her sting behind the basal region of its sinistral metacoxa, where the sting remained for a while. The grub emitted a greenish brown fluid from its mouth and lay motionless on sands vibrating slightly its mouth parts. It was 6:38 a.m.. She went down the burrow, came out, held its abdominal end and dragged it down the burrow. At 7:48 a.m. she came out and stayed still on sands about 15 minutes, by 8 a.m. when she began to fill the burrow with sands. One by one with her mandibles she grasped a sand particle and carried into the burrow. Seldom she scratched up sands near the entrance with her fore tarsi and raked backwards into the burrow through under her body. The prey's burrow which had been 6 cm long was filled in with sands 2 cm upwards from the bottom. The burrow was stopped up with the sand filling 2 cm long, leaving an empty cell of 1.3 cm long, that is the cell left by her for her offspring. At the entrance the tunnel was left unstuffed 5 mm long (vide the figure).

9) No. 4 (3)

The wasp was put into a jar, in which the grub had not yet made its burrow. She recognised immediately the grub walking on sands, rushed to it, clung to its dorsal surface of thorax grasping it behind the vertex with her mandibles and thrust her sting at a lateral point of the basal region of its dextral metacoxa.

10) No. 4 (4)

As soon as the wasp was put into a jar at 6:30 a.m., she went down the grub's burrow rapidly and soon came out. She entered once more into the burrow and came out again. On both occasions she did not attack the grub. Thirdly she went down and plunged her sting to it. It was observed through the glass wall that she stung the grub behind the gular region being grasped by it between its jaws.

11) No. 4 (7)

The wasp was put into the jar and soon irritated the grub which

jumped out of its burrow. When she finished to paralyze it on sands, both were removed into the second jar which had been filled with sands containing an artificial burrow 25 mm in depth. Then she drew it down into the burrow. Later on I found that the cell made for the wasp larva was 20 mm long from the bottom and the uppermost 5 mm was filled with sands.

12) No. 4 (8)

The wasp went down the burrow as soon as she was put into a jar and immediately the grub which was tightly grasping her by thorax in its long jaws appeared at the mouth of the burrow. On this occasion she was observed bending her abdomen and stinging it behind the gular region. She dashed to it and clung to its ventral side grasping it with her mandibles by its dextral procoxal region and thrust her sting behind the basal portion of the sinistral metacoxa and the fourth behind the sinistral one. Then she stopped to sting.

13) No. 4 (9)

Similar to the preceding observation, the wasp plunged her sting behind the gular region of the prey which came up the burrow grasping her in its jaws. On sands the second sting was thrust behind the proximal portion of the dextral metacoxa and the third the sinistral one.

14) No. 4 (11)

Similar to the above two notes, the wasp was observed stinging the grub behind the gular region when it appeared out of the burrow grasping her by her metathorax. It jumped out from its nest, yet holding her in its jaws. She slipped out from the jaws of the agitatedly walking larva. It walked about actively and tried hurriedly to climb up the glass wall. The first sting seemed to be ineffective. Soon she obliquely to the ventral surface of the running grub and stung it behind the basal part of the sinistral metacoxa. Next the third sting was thrust behind the basal part of the sinistral mesocoxa and the sting stayed there still for a while giving rise somewhat to bleed there. After this sting she went down the burrow, came up, and indicated a kind of burrowing-like action on sands. All her stings were yet quite ineffective and the grub walked about as it was. She once more clung to the lateral portion of its fifth abdominal segment, clawled quickly to the ventral side of the thorax, grasped it near its metathoracic sternum in her mandibles bending her abdomen

extremely and thrust a sting behind the basal part of the dextral metacoxa. But the larva exerted itself to climb up the glass wall as before. I suspended my observation, but I think that she might repeat her attack still more in vain. Next morning I found a miserable fact, namely the wasp had been devoured by that *Cicindela* grub and there her antennae, legs and several chitinized portions were found at the bottom of its burrow.

15) No. 7 (I) 〔Captured on July 27〕

The grub's burrow was 40 mm deep. After paralyzing and transporting the prey into the burrow, the wasp filled up the burrow with sands 5 mm long at the bottom, remained the 21 mm long space which was prefered for her own larva's cell and filled up the burrow 14 mm above the cephalothoracic shield of the prey.

16) No. 6 (4) 〔Captured on July 27〕

At 1:30 p.m. the wasp was put into a jar. As soon as she went down the burrow, the grub came up the burrow grasping her in its jaws by her mesothorax. The grub which had been stung by her behind the gular region set free her at the burrow entrance, jumped out of the burrow and lay on sands strongly curving its body ventrad. Quickly she crawled on its lateral surface, sought the stinging point and sensitively touched the prey's prothoracic sternum with her last abdominal segment; but she seemed not to plung her sting to it. Then her stings were thrust behind the dorsal plate of prothorax, the basal region of the sinistral metacoxa and next the dextral one. Moreover she plunged her sting into the body of the weakened grub, viz., behind the sinistral metacoxal base, behind the dextral one and two times behind the sinistral one. The larva became quite motionless. She went down the burrow, came up soon and pulled it down into the burrow.

17) No. 6 (6)

At 5:10 p.m. the wasp went down and soon came out of the burrow. The grub followed her and jumped out of the burrow quickly and lay still curving itself ventrad. She clung to its dorsal side grasping with mandibles by its dextral metacoxa and thrust her sting behind the basal portion of the sinistral metacoxa. After that she walked about on sands, scrubbing her abdomen on sands. Again she clung to the ventral side of its thorax in the same direction to it, seized its metasternum with her mandibles and plunged her sting into the proximo-caudal portion of the sinistral metacoxa. It became

completely motionless. She went down the burrow, came up and dragged it down grasping it at its abdominal end.

18) No. 6 (7)

The wasp went down the burrow as soon as she was transfered into a vessel. Soon she came up the burrow struggling with the grub and near the mouth of the burrow stung it twice behind the gular region. She walked about on sands for a while, crawled carefully on the body of the larva which had been already weakened and occupying the burrow entrance, and thrust a sting to it from its dextral side between the dorsal sides of the pro-and mesothorax. The next sting was thrust between the meso-and metacoxae and let it fall into a complete paralysis. The grub was paralyzed at the entrance and inserted its abdomen half into the burrow, so the wasp could not enter into the latter. She climbed up the glass wall, came out of the jar through the open lid and walked about round the jar on my desk. She seemed to be searching for a suitable burrow of the *Cicindela* grub but she could not find any burrow. For a while she came back into the vessel without escaping elsewhere. During her trip I removed the larva from the entrance on to the sands. Returning from the trip she went down the burrow, came up soon and transported it down into the burrow.

19) No. 11 (1) [Emerged on August 15]

The wasp was the daughter of the wasp No. 4 and had spent 4 days since her emergence from the cocoon. This was her very first encounter with the *Cicindela* grub.

She was put into a glass tube at 10 a.m. She walked in the vessel for 5 minutes and sometimes peeped into the burrow in which the grub was deep at the bottom, but she did not enter. Indeed she seemed to be very provident. For the first time at 10:05 a.m., she went down the burrow and soon the grub came up till the mouth of the burrow and stopped there motionless as it does normally. But she did not appear from the burrow. I drew it out of the burrow gently and found her clinging frst to the ventral surface of its thorax, venter to venter, in the same direction to it, grasping it near its prosternal region with her mandibles. On sands both she and her prey stayed still for 2 minutes in that condition. At last, in that position, she thrust her sting behind basal region of the dextral metacoxa. She set free her grasp and crawled about on and under the paralyzed larva continuously beating it with her vibrating antennae. It moved sometimes only convulsively. She went down, came up and

dragged it down into the burrow seizing it by the dorsal swelling of the 5th abdominal segment. By 4 p.m. she filled in the burrow completely.

20) No. 11 (5)

She went down and appeared from the burrow being grasped with the grub's jaws. Her abdomen was strongly curved ventrad and downwards between its jaws, and at last her sting was thrust behind the gular region on the mesal line near the burrow entrance. It jumped out on sands and was stung secondarily behind the basl portion of the sinistral mesocoxa and thirdly behind the base of the dextral metacoxa. It was half past noon. After 2 days I saw the larva walk a little even by a slight sticking stimulus.

21) No. 12 (3) 〔Emerged on August 8〕

The wasp plunged her sting into a mesal point behind the gular region of the grub when she went down the burrow and came up with the grub for the first time. The wasp stung it on sands continuously; viz., once behind the basal portion of the dextral mesocoxa, twice behind the same of the dextral metacoxa, twice behind the same of the sinistral metacoxa and at last once behind the same of the dextral metacoxa.

22) No. (6)

The wasp stung the grub behind the gular region near the mouth of the burrow, she came up after the first encounter with it. The grub came up and crawled out of the burrow. On sands she plunged her sting at first into behind the basal portion of the dextral mesocoxa and continuously behind the same of the dextral metacoxa. After 2 days, it was able to walk easily spontaneously.

23) No. 12 (8)

The wasp entered into the burrow, in which she stung the grub behind the gular region. Stimulated by this sting, the grub came up and jumped out of the burrow. On sands her stings were thrust once behind the basal portion of the sinistral mesocoxa and twice behind the same of the sinistnal metacoxa. After 20 hours, the paralyzed grub restored itself to the state somewhat responsible to the sticking stimulus applied to any point of the body.

24) No. 12 (9)

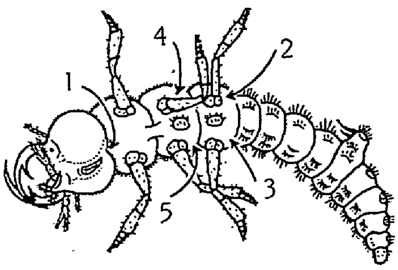
The wasp went down the burrow and immediately plunged a sting into a mesal point behind the gular region of the grub. It was

3 seconds later that the grub indicated a response to her stinging. Namely it ran up and down rapidly in its vertical tunnel several times. On the other hand, after thrusting her sting the wasp retreated back quickly out of the burrow and stayed still near the entrance directing her head carefully towards the burrow. After a while it stopped near the mouth. The poison seemed to take an effect and the paralysis was, indeed, quite complete. I drew it out of the tunnel with a slender hooked pin. Soon she dashed to it, clung to it and plunged her sting behind the basal portion of the sinistral procoxa. She dragged it down into the burrow grasping it by its abdominal extremity with her mandibles. I pulled it out once more. Quickly she came out of the burrow pursuing her prey, clung to its ventral surface in the same direction to it seizing by its prothoracic sternum with her jaws and stung behind the base of the dextral metacoxa. But it is not clear whether these second and third stings were only due to the artificial movement of the grub or due to the hereditary behavior characteristic to this species as well as the above examples.

B. Discussion of Habits

1) Stinging Habit

From 17 observations (indicated with *, in already mentioned table) the following 6 points on the body of the prey are known to have been stung by the wasp.



F g. 1.

Point No.	Location
1	On the mesal line behind the gular region
2	Behind the bese of the sinistral metacoxa
3	Behind the base of the dextral metacoxa
4	Behind the base of the sinistral mesocoxa
5	Behind the base of the dextral mesocoxa
6	On the mesal line behind the pronotum(cephalothoracic-shield)

The order of stinging in each of 17 cases and the frequency of

attack are shown by the point numbers as follows:—

	Obs. No.	Order of stinging: I	II	III	IV	V	VI	VII	VIII
M. yasumatsui	No. 5(1)	1							
	No. 5(2)	1							
	No. 18(1)	1							
M. japonica	No. 4(1)	1	2						
	No. 4(2)	1	2						
	No. 4(8)	1	2	3	2				
	No. 4(9)	1	3	2					
	No. 4(11)	1	2	4	3				
	No. 6(4)	1	6	2	3	2	3	2	2
	No. 6(6)	1	2	2					
	No. 6(7)	1	1	6	4				
	No. 11(1)	1	3						
	No. 11(5)	1	4	3					
	No. 12(3)	1	5	3	3	2	2	3	
	No. 12(6)	1	5	3					
	No. 12(8)	1	4	2	2				
	No. 12(9)	1	1	3					

Point No.	1	2	3	4	5	6
M. yasumatsui	3					
M. japonica	16	16	12	4	2	2
Total	19	16	12	4	2	2

The stinging point which both species most often attack is found to be behind the gular region on the mesal line and *M. yasumatsui* stings only this point. The important stinging points of *M. japonica* are Nos. 1,2 and 3 and on either of the latter two points the egg is deposited afterwards. The female of *yasumatsui* stung the prey on the point No. 1 only once and paralyzed it completely as well, while the female of *japonica* stung various points and the first sting behind the gular region benumbs the prey imcompletely. The sting of the former is so effective and quick in result that in every case the stung larva

was not able to escape out of the burrow. After delivering a sting the female of *yasumatsui* retreats out of the burrow and waits for a while, while the poison is taking effect. On the other hand the larva stung by the female of *japonica* jumps out of the burrow, almost in every case, (the female No. 12 (9) of *japonica* acted quite similarly as *yasumatsui*) and the succeeding stings are, therefore, delivered out of the burrow. In this case the stinging seems to be a mere response to the moving of the prey and to be continued until the prey becomes moderately quiet. Indeed, if the completely paralyzed prey is moved artificially with a hooked pin or forceps, the wasp begins to attack the prey again. But the motion of the prey is not considered to be the only limiting factor of continuing the attack. For examples, in the cases of No. 6 (4) and No. 12 (3), the wasp rendered the preys completely immobile, as the consequence of the first sting behind the gular region but they kept on stinging at several more points. The duration of the paralysis is quite differnt between the two species. The larvae stung by *yasumatsui* remain in complete paralysis without ever recovering, while those attacked by *japonica* recover from paralysis soon afterwards. The degree of paralysis of the preys after 24 hours are classified as follows:

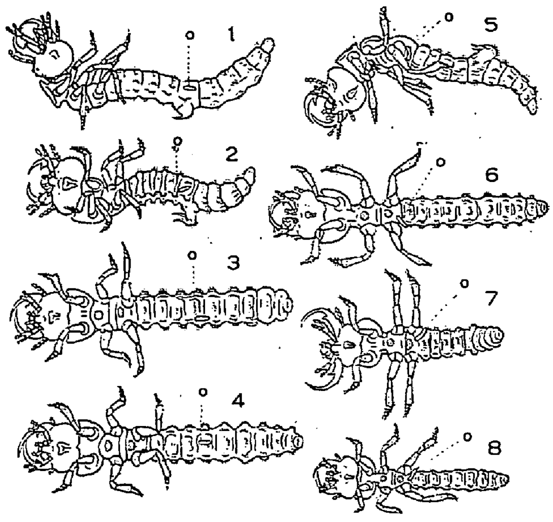


Fig. 2.

Larvae of *Cicindela specularis* with the eggs of *Methoca yasumatsui* (1—4) and *Methoca japonica* (5—8).

1=No. 5 (1); 2=No. 5 (2); 3=No. 5 (4); 4=No. 5 (5); 5=No. 4 (5); 6=No. 7 (1); 7=No. 4 (2); 8=No. 4 (10).

(a) 23 larvae stung by *M. yasumatsui* were all completely motionless and did not respond to the pin-sticking stimulus applied to any part of the body.

(b) 42 larvae stung by *M. japonica* all responded to the pin-sticking stimulus.

(a′) 23 larvae could walk normally and some of them could burrow in sands.

(b′) 14 larvae could move their abdomen, legs and mouthparts, but could

not move coordinately.

(c′) 5 larvae moved only the mouthparts convulsively.

2) Oviposition Habit

The condition of paralysis and the position of the egg seem to be closely related in these two species. *M. yasumatsui* deposits an egg longitudinally on the ventral surface of the 3rd—5th abdominal segment of the prey which never recovers from paralysis, while *M. japonica* oviposited transversely behind the metacoxa of the prey which recovers soon afterwards. The latter position protects the egg from danger caused by the active moving of the restored prey.

M. yasumatsui

Obs. No.	Egg Position	Obs. No.	Egg Position
No. 5 (1)	d. 5th	No. 15 (1)	s. 4th
No. 5 (2)	d. 5th	No. 15 (2)	s. 4th
No. 5 (3)	d. 5th	No. 15 (3)	s. 4th—5th
No. 5 (4)	d. 5th	No. 15 (4)	s. 4th
No. 5 (5)	m. 4th	No. 15 (6)	s. 4th
No. 5 (6)	s. 4th	No. 15 (8)	s. 3rd—4th
No. 5 (8)	m. 4th—5th	No. 18 (1)	s. 4th
No. 5 (10)	m. 5th	No. 18 (2)	s. 4th
No. 5 (11)	m. 4th	No. 18 (3)	s. 4th
No. 5 (12)	s. 5th	No. 18 (4)	s. 4th

M. japonica

Obs. No.	E. P.	Obs. No.	E. P.	Obs. No.	E. P.	Obs. No.	E. P.
No. 4 (1)	sc	No. 6 (3)	dc	No. 11 (4)	sc	No. 12 (6)	sc
No. 4 (2)	sc	No. 6 (5)	sc	No. 11 (5)	dc	No. 12 (7)	sc
No. 4 (3)	sc	No. 6 (6)	dc	No. 11 (6)	sc	No. 12 (8)	dc
No. 4 (5)	sc	No. 6 (7)	dc	No. 11 (7)	sc	No. 12 (9)	sc
No. 4 (6)	sc	No. 7 (1)	dc	No. 11 (8)	sc	No. 12(10)	dc
No. 4 (7)	sc	No. 7 (2)	dc	No. 12 (1)	sc	No. 14 (1)	sc
No. 4 (8)	sc	No. 7 (3)	dc	No. 12 (2)	dc	No. 14 (2)	sc
No. 4 (10)	sc	No. 11 (1)	sc	No. 12 (3)	sc		
No. 6 (1)	sc	No. 11 (2)	dc	No. 12 (4)	dc		
No. 6 (2)	sc	No. 11 (3)	dc	No. 12 (5)	dc		

s. (d.) 3rd (4th, 5th), somewhat sinistrad (dextrad) on the meson of the 3rd (4th, 5th) abdominal segment; m, on the mesal line; 4th—5th (3rd—4th), between the 4th and 5th abdominal segment; sc. (dc.), behind the base of the sinistral (dextral) metacoxa.

A perusal of this table seems to indicate that the exact site selected for oviposition is either a matter of chance or due to individual idiosyncrasy.

The egg of *M. yasumatsui* is deposited anywhere on the ventral surface of the prey's abdomen, with its cephalic end directed towards the head of the victim. The egg of *M. japonica* is fixed always behind the base of the metacoxa, with its cephalic end directed toward the mesal line of the prey. The location[9] of the eggs seems to be so related to the subsequent activity of the paralyzed prey that it affords proper protection to the eggs, since the prey of *M. japonica* recovers from paralysis soon and moves actively up and down the burrow whereas that of the other species never regains activity and remains motionless.

3) Two types of habits in *Methoca*

F. X. Williams distinguished two types of structures in his study of the Philippine species of *Methoca* represented by *M. ichneumonides* Latreille and *M. striatella* Williams. The former is stout bodied and has a rectangular head, while the latter is slender and has a subtriangular head. *M. japonica* clearly belongs to the former group as already mentioned by Mr. Yasumatsu (1931) and *M. yasumatsui* to the latter. The habits of the females of these two groups are also divisible in two types as follows:

Species	Body	Effect of paralysis	Position of egg on prey
ichneumonides Latreille	stout	temporary recoverable	Behind metacoxa
stygia Say	stout	temp. recov., or fatal	Behind metacoxa
punctata Williams	stout	temp. recov.	On underside of metathorax

9) Shelford has studied a bee-fly (*Spogostylum anale* Say), a parasite of an American tiger beetle (*Cicindela scutellaris* var. *lecontei* Hald.) larvae. The young larva of this parasitic Diptera also clings between the legs of the active host. (Ann. Ent. Soc. Amer,. Vol. 6, 217—219).

Species	Body	Effect of paralysis	Position of egg on prey
japonica Yasumatsu	stout	temp. recov.	Behind metacoxa
striatella Williams	slender	enduring, not recov.	On underside of III-IV abdominal segment
yasumatsui	slender	enduring not recov.	On underside of III-V abdominal segment

From the above and other points of view it seems that *ichneumonides* type is more primitive than *striatella* type as a hunting wasp.

4) Nesting Habit

These two species of *Methoca* are regarded not as a simple parasite of the *Cicindela* grub but rather as a considerably specialized hunting wasp, although their females never prepare their own burrow or nest before they find and paralyze their prey; for she transports her prey into the burrow from outside or moves it inside of the burrow and fills up the burrow after having finished to transport or orientate the prey and deposits an egg upon it. The female of *yasumatsui* stings her prey so effectively and the prey falls so rapidly into the complete paralysis within the burrow, in many cases at the entrance, that she only orientates her prey inside her burrow. But many observations on *japonica* show that after her first sting the prey jumps out of the burrow and tries to escape from her. So after her consequent pursuit and several stings, she must drag it back into the burrow which has belonged to her prey itself and now belongs to herself. These seem to the first step or a transition to the transporting habit of other so-called higher hunting wasps. But on the other hand the prey of these wasps is extremely heavy for them. For instance, a female of *yasumatsui* was 0.2 mg. in weight, while one of her prey, a larva of *Cicindela specularis*, was 39 mg. (weighed at 11 a.m., July 15, 1932), which is about two hundered times her weight. Thus the unbalanced state of their weights seems to induce the wasp to be unable to transport her prey from a distance and so to remain in the parasitic wasp type.

In many cases both species drag the grub with her backwardly grasping by its abdominal end with her mandibles, in certain cases (vide No. 11 (1)) they were observed transporting the prey seizing by

the dorsal swelling of its 5th abdominal segment. But generally, when they pull the prey down the burrow, their grasping point is regarded as the abdominal end. Few minutes after drawing down the tunnel the wasp was often observed to pull it up the burrow backwardly, grasping by its mouth appendages with her mandibles. Shortly she draws it down again. Thus the preserved prey is always directing its head upward. When the wasp closes the burrow, the prey's cephalothoracic shield itself becomes a very fit lid for the hole and the sand stuff is filled in above this lid. The wasp sometimes scratches the sand with her anterior legs into the burrow, but in general she takes one by one a small pebble found outside near the entrance with her mandibles, carrys it into the burrow and drops it. Sometimes she presses the sand surface with her clypeus. In *yasumatsui* as already stated (No. 5 (2)), a female was observed ramming down the filled burrow with a pebble seized in her mandibles. This is somewhat like the method applied by some *Ammophila*[10] wasps in the course of filling in the stocked burrow. This action has not yet observed in *japonica* by this time. As for the closing habit there seems to be no difference between two species and to be no definite type in each of both species.

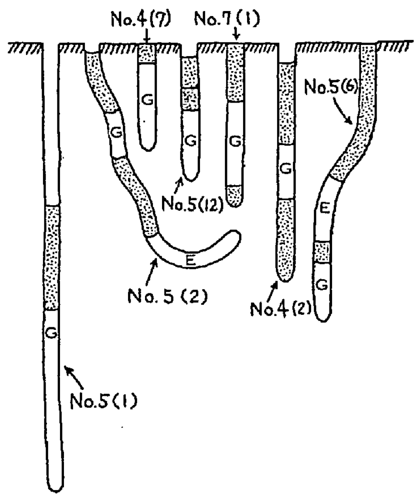


Fig. 3.
E : empty cell;
G : preserved *Cicindela*-grub

10) *Ammophila yarrowi*—S. W. Williston (1892) 〔Ent. News, III, 4, pp. 85—86〕
Ammophila urnaria—G. W. & E. G. Peckham (1898) 〔Wisc. Geol. & Nat. Hist. Surv. II, pp. 22—23〕
Ammophila procera—C. Hartman (1905) 〔Trans. Tex. Acad. Sc. 7, pp. 32—33〕
Ammophila sp.—H. B. Hungeaford & F.X. Williams (1912) 〔Ent. News, XXIII, 6, pp. 245—246〕
Ammophila pictipennis—P. & N. Rau (1918) 〔Wasp Studies Afield, pp. 214—216〕
Psammocharidae and Sphecidae, collected Records of their Different Methods of Filling in the Stocked Burrow—G. D. H. Carpenter (1930) 〔Trans. Ent. Soc. London, LXXVIII, pp. 283—308〕

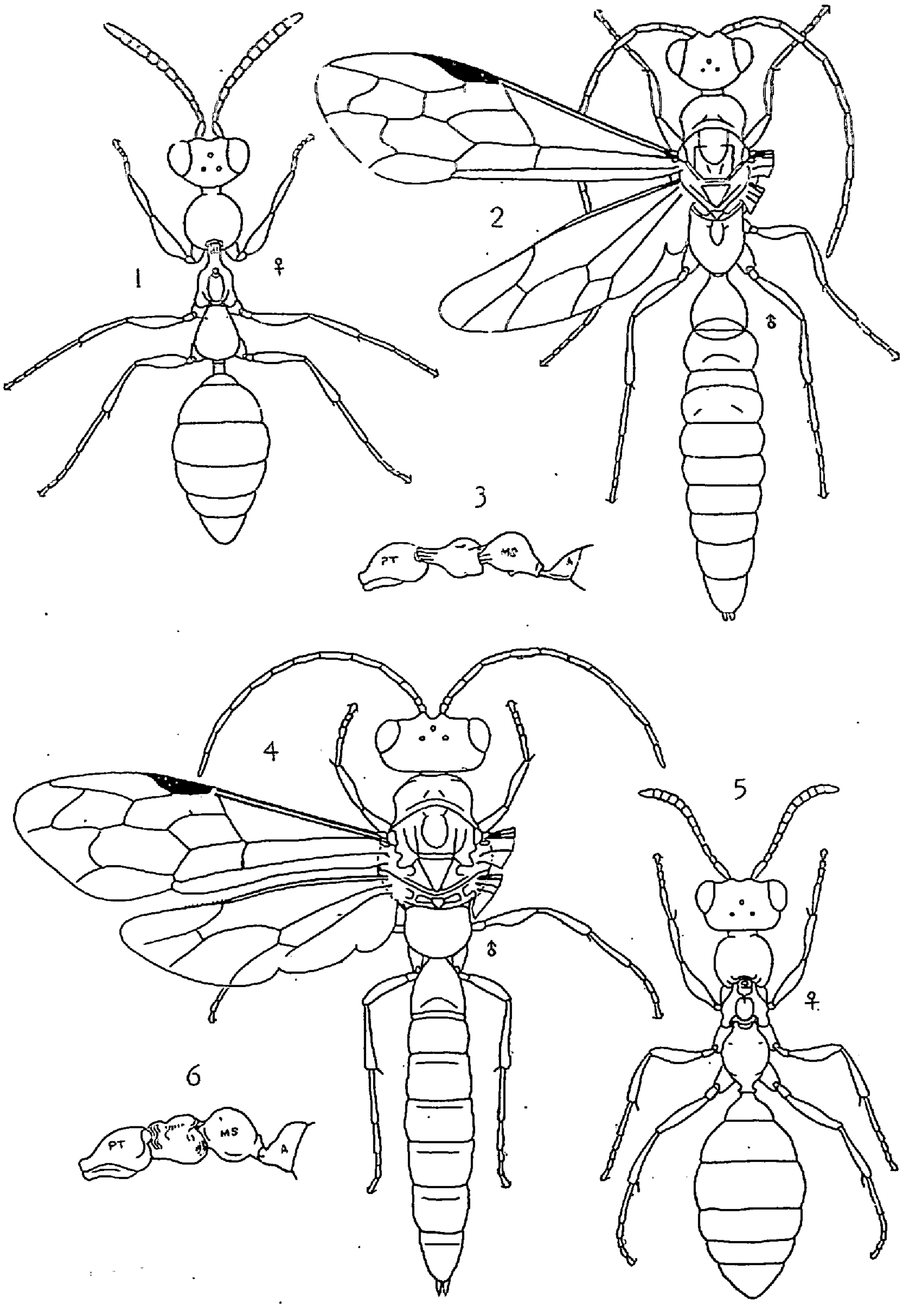


Fig. 4.
Methoca yasumatusi
1 ; female., 2 ; male; 3 ; lateral aspect of thorax.
Methoca japonica
4 ; male, 5 ; female; 6 ; lateral aspect of thorax.

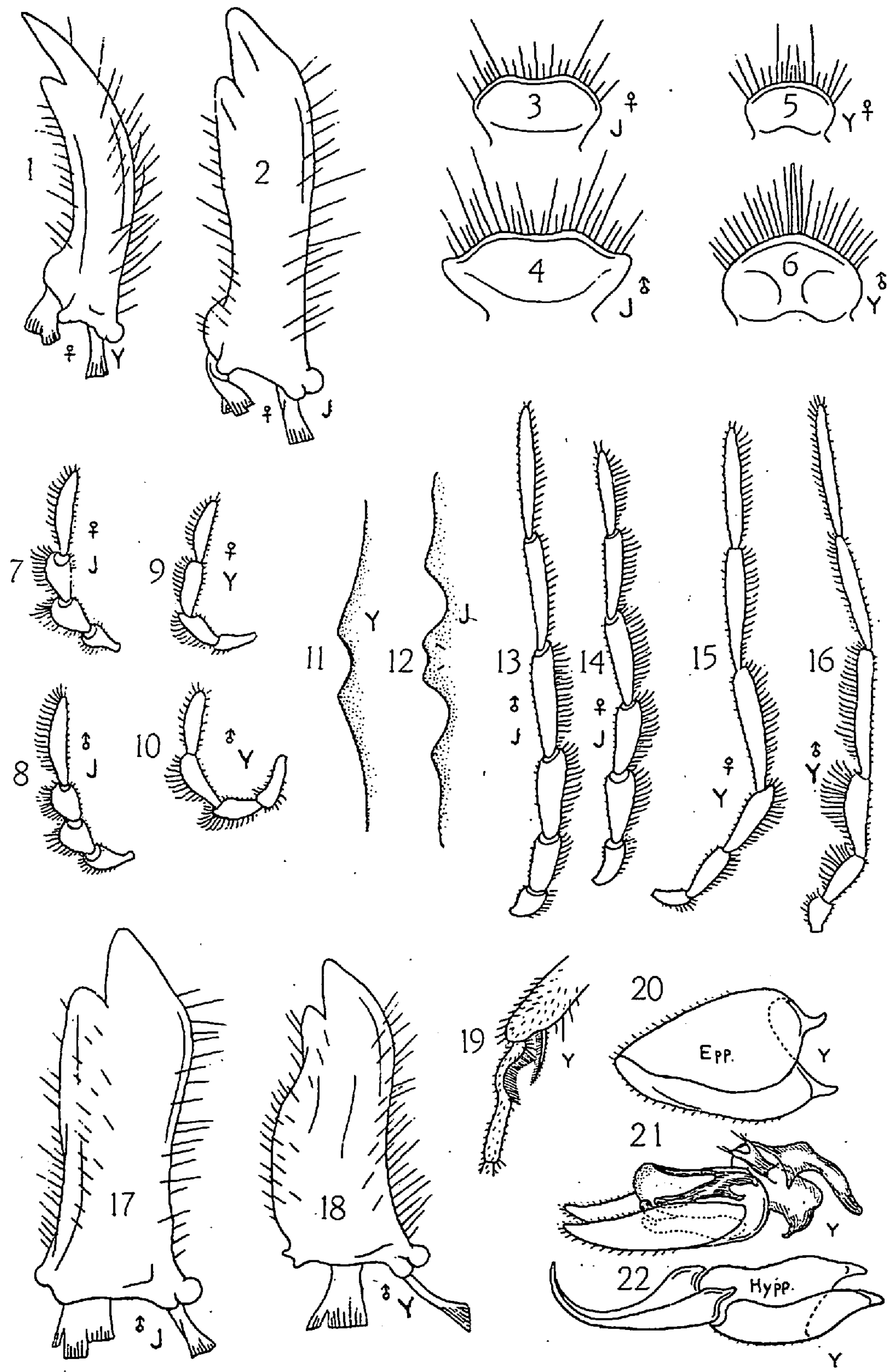


Fig. 5. Y : *Methoca yasumatusi*; *J* : *Methoca japonica*
1—2 ; dorsal aspect of mandible of female; 3—6 ; ventral aspect of labrum; 7—10 ; labial palpus; 11—12 ; clypeus margin of male; 13—16 ; maxillary of male; 17—18 ; mandible of male; 19 ; cleaning apparatus of female; 20—22 : pygidium and genitalia of male.